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Submitted herewith for filing is the patent application of Inventor(s):

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For: **Method to Infer Engine Coolant Temperature in Cylinder Head Temperature Sensor Equipped Vehicles**

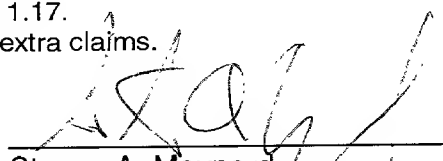
Enclosed are:

- ☒ 2 sheet(s) of drawings
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**METHOD TO INFER ENGINE COOLANT TEMPERATURE IN CYLINDER
HEAD TEMPERATURE SENSOR EQUIPPED VEHICLES**

BACKGROUND OF THE INVENTION

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1. Field of the Invention

The present invention relates generally to an automotive engine coolant temperature determination method. More particularly, the present invention relates to a method using a cylinder head temperature sensor to infer such a temperature.

2. Disclosure Information

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It is well known that malfunctions of engine cooling systems, such as a leak, will generally cause damage to the engine due to excessive engine overheating. To indicate such an event, a temperature sensing system for an internal combustion engine may include an engine coolant temperature (ECT) sensor, a cylinder head temperature (CHT) sensor, or a combination of the two. The temperature sensors record a temperature and relay the information to an electronic engine controller, which, in turn, relays the information to an operator, typically via an instrument display panel.

In ECT sensor equipped vehicles the sensor typically communicates with a coolant passage in a cylinder head. The problem with ECT sensor equipped vehicles is that an accurate reading of the CHT can not be obtained. Having an accurate CHT reading is important with respect to fuel economy and emissions.

In CHT sensor equipped vehicles the sensor typically communicates with the cylinder head at a location adjacent the combustion chamber of the engine. A problem with CHT sensor equipped vehicles is that the ECT can not be accurately calculated. For example, the CHT can be up to

70 degrees Fahrenheit hotter than the ECT and the temperature gauge would read hot when the system is really operating within a normal temperature range, thereby giving a "false reading".

5 To combat these problems many vehicles are equipped with both ECT and CHT sensors. A problem with a two sensor system is that it is more costly than the single sensor systems. A further problem is that the algorithm
10 programmed into the engine controller is more complex because of the need to receive information from two sensors.

 It would therefore be desirable to provide a method of accurately inferring ECT in CHT sensor equipped vehicles that overcomes the deficiencies associated with previous
15 systems.

SUMMARY OF THE INVENTION

 The present invention overcomes the disadvantages of
20 the prior art approaches by providing a method of inferring ECT in CHT sensor equipped vehicles including the steps of measuring the CHT, calculating the ECT from the measured CHT as a function of at least one vehicle operational state, generating a signal for the calculated ECT, and
25 sending the generated signal to a display.

 It is an object and advantage of the present invention to calculate ECT as a function of the vehicle operational state. Calculation in this fashion prevents "false readings" which may arise when CHT is running hotter than
30 ECT, but still within an acceptable operational range.

 A feature of the present invention is to filter the calculated ECT to prevent inaccurate display readings resulting from sudden changes in vehicle operational states, the filter step being performed prior to the step
35 of generating a signal.

These and other advantages, features and objects of the invention will become apparent from the drawings, detailed description and claims which follow.

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BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a perspective view of an automotive vehicle according to the present invention;

Figure 2 is a partial cross-sectional view of an
10 internal combustion engine having a temperature sensing system according to the present invention; and

Figure 3 is a flow chart showing a method for inferring ECT in CHT sensor equipped vehicles according to the present invention.

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DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings, Figure 1 shows an automotive vehicle 10 having an internal combustion engine
20 12 and a dashboard 14 housing an instrument display panel 16. As known in the art, the display panel 16 has a variety of gauges which communicate various vehicle operational states such as vehicle speed, engine revolutions per minute, and engine temperature for example.

25 A temperature sensing system 11, shown in Figure 2, infers ECT from a measured CHT. The engine 12 includes a cylinder block 18 having a cylinder 20 formed therein and a piston 22 reciprocally housed within the cylinder 20. A cylinder head 24 is mounted to the cylinder block 18, with
30 a cylinder head gasket 26 disposed therebetween, such that the cylinder head 24 closes the outer end of the cylinder 20, thereby defining a combustion chamber 28 between the top of the piston 22 and an insulation deck 30 of the cylinder head 24. A sparkplug 32 is fastened to the
35 cylinder head 24 to communicate with the combustion chamber 28. A cooling system 34 of the engine 12 is generally

provided by a coolant passage 36 formed in the cylinder head 24. A coolant 38 circulates in coolant passage 36 to cool the engine 12.

According to the present invention, a temperature
5 sensor 42 communicates with the insulation deck 30 in the cylinder head 24 adjacent the combustion chamber 28. Preferably, the temperature sensor 42 is a thermistor as is known in the art. The temperature sensor 42 senses the cylinder head 24 temperature and relays the information to
10 an electronic engine controller (EEC) 44 having a keep alive memory (KAM) storage device 46.

Referring now to Figure 3, according to the present invention, a method of inferring ECT from a CHT sensor is described. At step 50, the process is initiated. At step
15 52, it is determined whether a CHT is available from the EEC. If not, then at step 54 the engine temperature signal generated and sent to the display 16 (ECT DISPLAY) is set equal to a failure mode value of ECT (ECT FMEM). Generally, the engine temperature signal generated and sent
20 to the display 16 at step 54 equals the combustion chamber air charge temperature during a cold start, and ramps to a calibratable constant whose value is typical for a warm engine.

If a valid CHT is available, then at step 56, it is
25 determined whether the initial pass through this process has been completed (INIT FLG). The initial pass completed is indicated by a 1 as discussed below.

If the initial pass was completed, then at step 58, a temporary ECT value is determined. This temporary value is
30 equal to the CHT value minus a first function (F1(RPM, LOAD)) plus a second function (F2(CHT)). The first function is derived from a calibratable look up table showing the deviation of ECT from CHT as a function of revolutions per minute (RPM) and cylinder air charge
35 temperature (LOAD). Both RPM and LOAD values may be derived from the EEC. The second function is to account

for the difference between ECT and CHT increases for very high values of CHT.

At step 60, the engine temperature signal generated and sent to the display 16 (ECT DISPLAY) is set equal to a rolling average function (ROLAV) used to filter out noise. The rolling average function is determined as a function of the temporary ECT value and a calibratable time constant (RUN TC) that takes into consideration the fact that CHT heats faster than the engine coolant.

At step 62, the temperature difference (DELTA) is determined and stored. The DELTA is the difference between the CHT and the engine temperature signal generated. The DELTA is sent to the display 16 and is stored in KAM, so that the DELTA at power-down is available during the next power-up. At step 64, the process ends.

If the pass at step 56 was not completed, then the process flow moves to step 66, where DELTA is determined as a function of the last DELTA stored in KAM multiplied by an exponential decay function (EXP). The EXP is a function of the number of minutes the engine 12 has been powered down (SOAKTIME) divided by a calibratable time constant (SOAK TC), which determines the rate at which DELTA decays during a soak. This information is available from the EEC 44. The EXP is equal to 1 if SOAKTIME equals zero and decays to zero as SOAKTIME approaches infinity. At step 68, the engine temperature signal generated and sent to the display 16 is equal to the difference between the CHT and the DELTA from step 66. At step 70, INIT FLG is registered as 1 indicating that the initial pass has been completed. At step 64, the process ends.

The present invention is advantageous for a number of reasons. First, because ECT is calculated as a function of the vehicle operational state "false readings" are avoided. For example, "false readings" which may arise when CHT is running hotter than ECT, but still within an acceptable operational range. Further, filtering the calculated ECT

prevents inaccurate display readings resulting from sudden changes in vehicle operational states. More specifically, because ECT is being inferred by CHT as a function of RPM and LOAD, anomalous readings for RPM and LOAD need to be
5 taken out of the calculation as they tend to change faster than actual CHT and ECT. In other words, if ECT is being inferred at a time when there is a sudden spike in RPM, with the RPM then returning to normal running, without filtering, the ECT calculation would indicate being out of
10 control limits when that is not actually the case. It is an important aspect of the invention, therefore, that not only is ECT inferred from CHT as a function of vehicle operational states, but also that the ECT sent to the display is filtered to eliminate noise resulting from the
15 various operational states.

Various other modifications to the present invention will, no doubt, occur to those skilled in the art to which the present invention pertains. It is the following claims, including all equivalents, which define the scope
20 of the present invention.

CLAIMS

What is claimed is:

1. A method of inferring engine coolant temperature in cylinder head temperature sensor equipped vehicles comprising the steps of:
 - measuring the cylinder head temperature;
 - 5 calculating the engine coolant temperature from the measured cylinder head temperature as a function of at least one vehicle operational state;
 - generating a signal for the calculated engine coolant temperature; and
 - 10 sending the generated signal to a display.
2. A method according to claim 1, wherein the vehicle operational state is engine revolutions per minute.
- 15 3. A method according to claim 2, wherein the vehicle operational state is cylinder air charge temperature.
4. A method according to claim 1, wherein the vehicle operational states are both engine revolutions per minute and cylinder air charge temperature.
- 20 5. A method according to claim 1, further including the step of filtering the calculated engine coolant temperature so as to prevent inaccurate display readings resulting from sudden changes in vehicle operational states, the filter step performed prior to the step of generating a signal.
- 25 6. A method according to claim 5, further including the step of recording the difference between the measured cylinder head temperature and the filtered engine coolant temperature.
- 30

7. A method according to claim 6, further including the
step of storing the recorded difference in keep alive
35 memory.

8. A method according to claim 7, further including the
steps of:

decaying the difference between the measured cylinder
40 head temperature and the filtered engine coolant
temperature as an exponential function of soak time upon
vehicle startup;

generating an initial, startup signal by subtracting
the measured cylinder head temperature from the last
45 recorded difference stored in keep alive memory; and
sending an initial, startup signal to the display.

9. A method of inferring engine coolant temperature in
cylinder head temperature sensor equipped vehicles
50 comprising the steps of:

measuring the cylinder head temperature;
calculating the engine coolant temperature from the
measured cylinder head temperature as a function of engine
revolutions per minute and cylinder air charge temperature;
55 generating a signal for the calculated engine coolant
temperature; and
sending the generated signal to a display.

10. A method according to claim 9, further including the
60 step of filtering the calculated engine coolant temperature
so as to prevent inaccurate display readings resulting from
sudden changes in revolutions per minute and air charge
temperature, the filtering step performed prior to the step
of generating a signal.

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11. A method according to claim 10, further including the
step of recording the difference between the measured
70 cylinder head temperature and the filtered engine coolant
temperature.

12. A method according to claim 11, further including the
step of storing the recorded difference in keep alive
75 memory.

13. A method according to claim 12, further including the
steps of:

decaying the difference between the measured cylinder
80 head temperature and the filtered engine coolant
temperature as an exponential function of soak time upon
vehicle startup;

generating an initial, startup signal by subtracting
the measured cylinder head temperature from the last
85 recorded difference stored in keep alive memory; and
sending an initial, startup signal to the display.

14. A system for inferring engine coolant temperature in
cylinder head temperature sensor equipped vehicles
90 comprising:

a cylinder head temperature sensor; and
a controller for calculating the engine coolant
temperature from the measured cylinder head temperature as
a function of engine revolutions per minute and cylinder
95 air charge temperature, wherein the controller generates a
signal for the calculated engine coolant temperature and
sends the generated signal to a display.

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15. A system according to claim 14, wherein the controller
105 further filters the calculated engine coolant temperature
so as to prevent inaccurate display readings resulting from
sudden changes in revolutions per minute and air charge
temperature, the filtering performed prior to generation of
the signal.

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16. A system according to claim 15, wherein the controller
further records the difference between the measured
cylinder head temperature and the filtered engine coolant
temperature.

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17. A system according to claim 16, wherein the controller
further stores the recorded difference in keep alive
memory.

120 18. A system according to claim 17, wherein the controller
further:

decays the difference between the measured cylinder
head temperature and the filtered engine coolant
temperature as an exponential function of soak time if
125 determined that the cylinder head temperature measurement
was taken at vehicle startup;

generates an initial, startup signal by subtracting
the measured cylinder head temperature from the last
recorded difference stored in keep alive memory; and

130 sends an initial, startup signal to the display.

ABSTRACT

The present invention provides a method of inferring the engine coolant temperature in cylinder head temperature sensor equipped vehicles including the steps of measuring the cylinder head temperature, calculating the engine
5 coolant temperature from the measured cylinder head temperature as a function of at least one vehicle operational state, generating a signal for the calculated engine coolant temperature, and sending the generated signal to a display.

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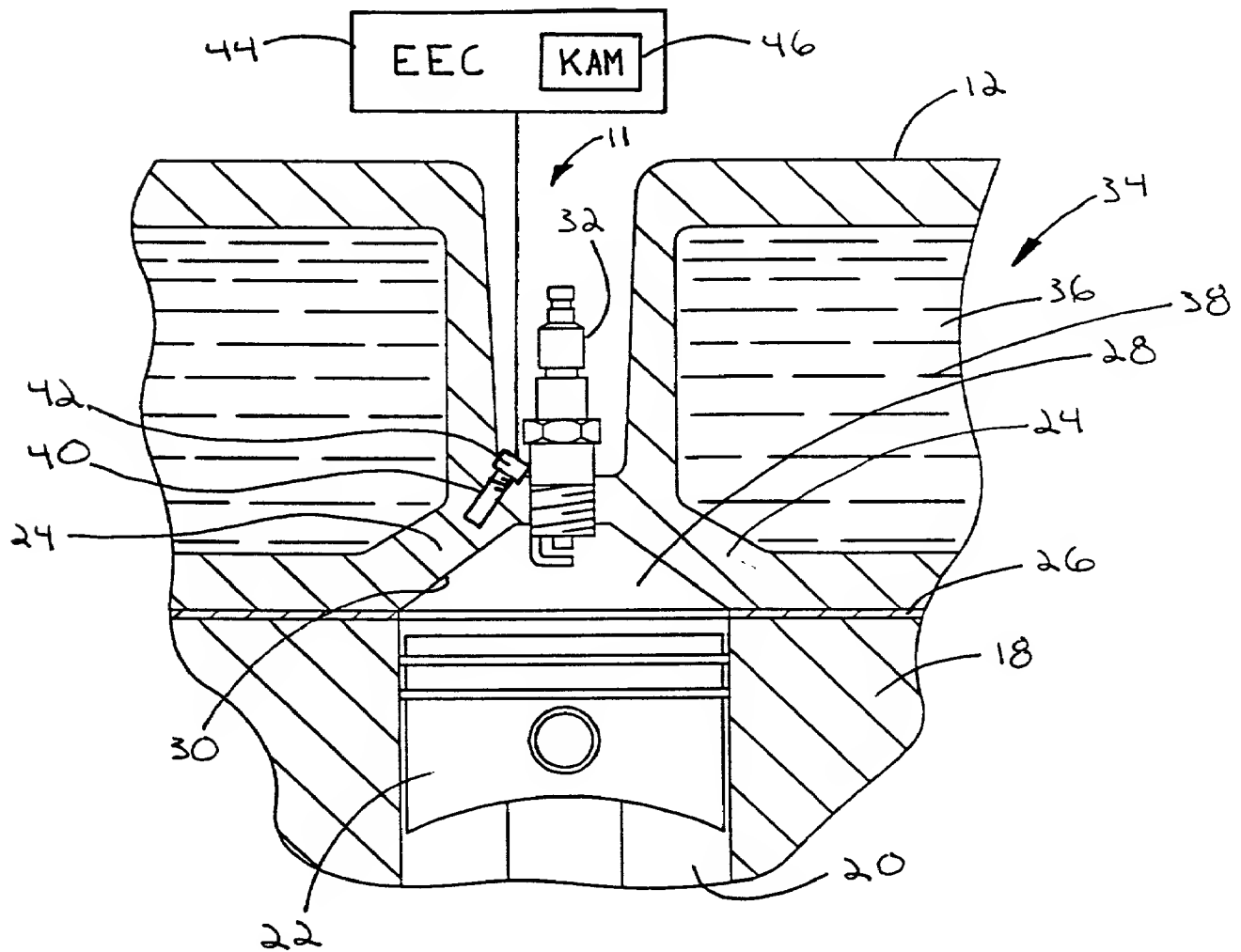
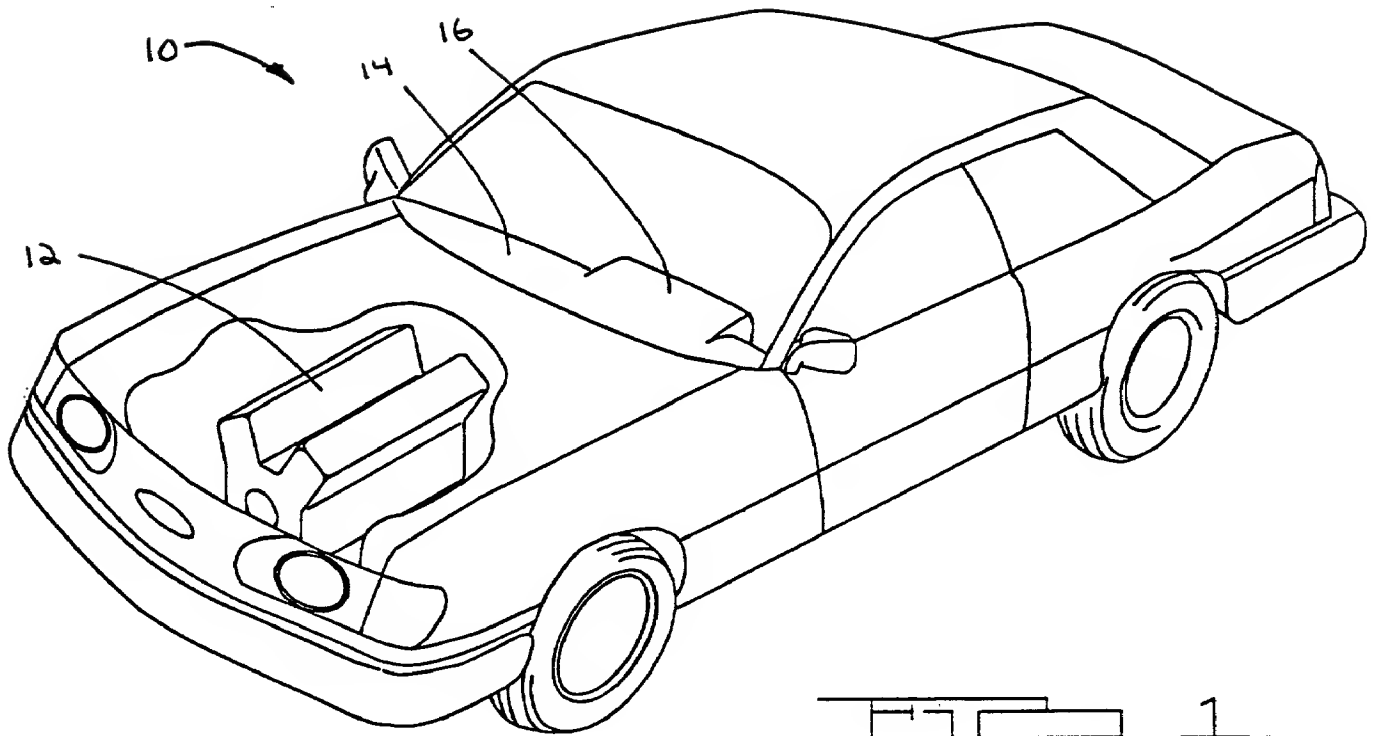


FIG. 2.

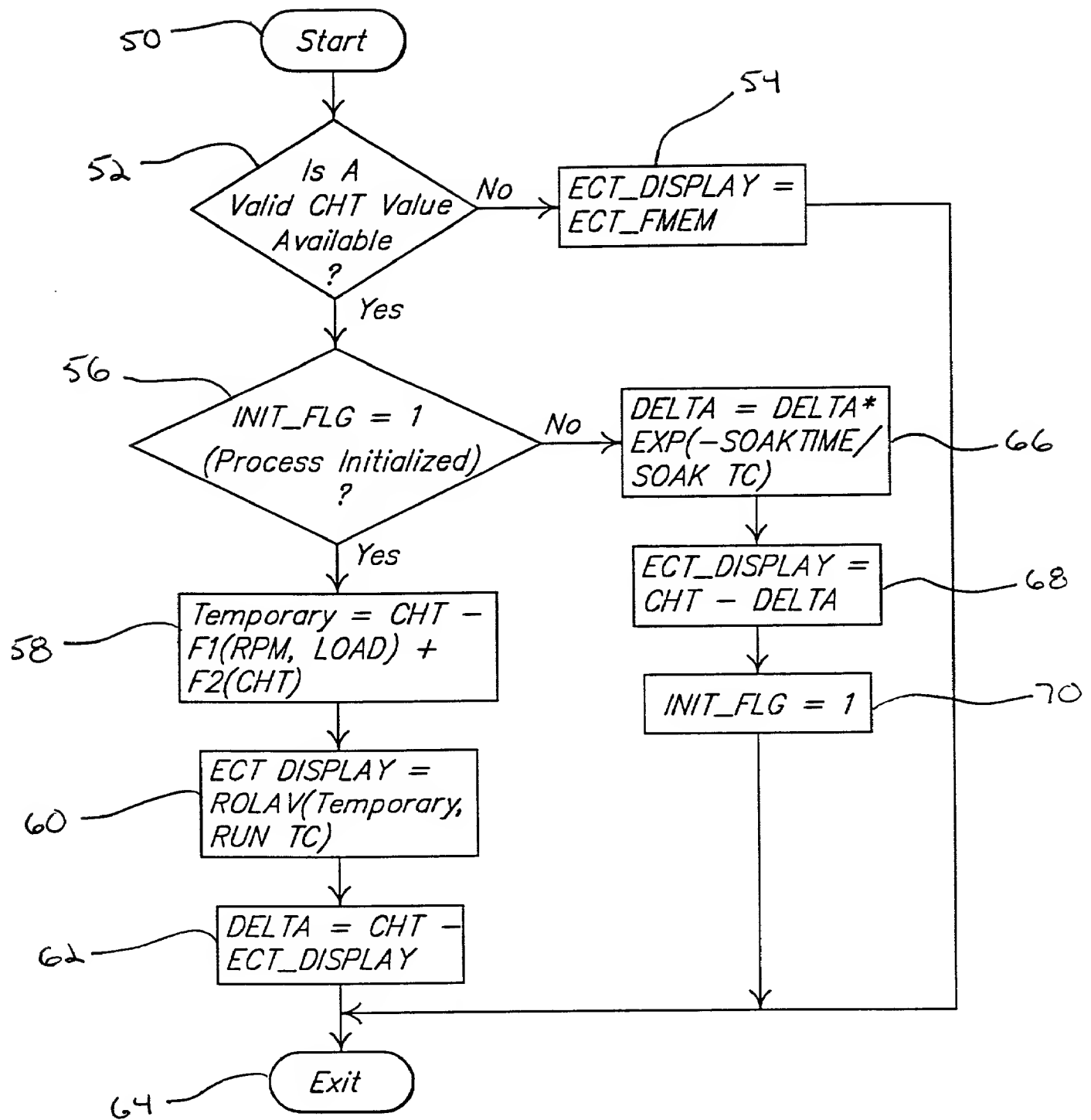


FIG. 3.

DECLARATION AND POWER OF ATTORNEY - ORIGINAL APPLICATION

Attorney's Docket No.
197-1096

As a below named inventor, I hereby declare:

My residence, post office address and citizenship are as stated below next to my name;

I verily believe I am the original, first and sole inventor or an original, first and joint inventor of the subject matter that is claimed and for which a patent is sought on the invention entitled

Method to Infer Engine Coolant Temperature in Cylinder Head Temperature Sensor Equipped Vehicles

the specification of which is attached hereto.

I have reviewed and understand the contents of the specification identified above, including the claims.

I acknowledge my duty to disclose information of which I am aware that is material to the examination of this application in accordance with Section 1.56(a), Title 37 of the Code of Federal Regulations; and

as to application for patents or inventor's certificate on the invention filed in any country foreign to the United States of America, prior to this application by me or my legal representatives or assigns,

☒ no such applications have been filed, or

☐ such applications have been filed as follows:

COUNTRY	APPLICATION NO.	DATE OF FILING (day, month, year)	DATE OF ISSUE (day, month, year)	PRIORITY CLAIMED UNDER 35 USC 119

I hereby claim the benefit under 35 U.S.C. § 120 of any United States application(s) or § 365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U.S.C. § 112, I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR § 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of this application.

(Application Number)

(Filing Date)

(Status - patented, pending, abandoned)

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(Filing Date)

(Status - patented, pending, abandoned)

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the United States Patent and Trademark Office connected therewith and to act on my behalf before the competent International Authorities in connection with any and all international applications filed by me.

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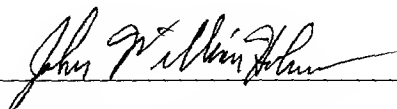
I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

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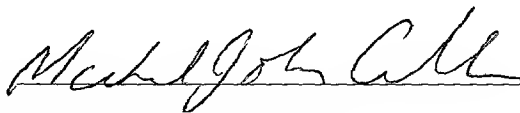
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